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AN AGENDA FOR A STUDY OF U.S.
TECHNOLOGY POLICY

R E P O R T

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TECHNOLOGY POLICY TASK FORCE

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1. INTRODUCTION

The year 1987 marks the 200th anniversary of the Constitution of the United States of America. It is a time of pride and of patriotic reflection. We are blessed to be living in the most affluent, the most free, and the most universally-envied nation of the world. Our nation stands as a symbol of freedom, social mobility and growth throughout the world.

Although the American system still offers much more than any other society, not every prospect pleases. Many of our major industries have declined. Other industries are kept functional through direct government intervention. Some segments of the economy are seeking protection from foreign competitors who are striving to take over international markets. Meanwhile the national debt grows to more than 2 trillion dollars so that the annual interest on our debt is at 15% of the federal budget, or roughly \$150 billion. Thus there seem to be portents of a national future that could be less affluent, less respected, and less influential in the community of nations.

As a nation we do not know with certainty the seriousness of our circumstances. Further, we do not know how much of our perceived plight may be due to poor management and poor planning, and how much may be due to the unavoidable flow of history. A cold-eyed assessment can help us correct what is amenable to correction, and adapt to what is inevitable.

During the 99th Congress, this Committee, then known as the Committee on Science and Technology, undertook a study of science policy. That study is currently in its completion stages. (It was generally anticipated that the Science Policy Study would probably be a precursor for a Technology Policy Study.) Furthermore, the skepticism about American pre-eminence in the technological arena continues, and the need for a study on technology policy is even more urgent. In this historic 100th Congress, it is our intention to initiate a thorough inquiry of our present technological position in the international community and to offer measures which may be taken to optimize our future.

This effort by our Committee is by no means isolated or unique. There is a plethora of forums, caucuses, initiatives, symposiums, and studies all designed to analyze and seek out solutions to the problems concerned with our nation's competitive posture.

What is unique is that the Committee on Science, Space, and Technology has both the legislative jurisdiction and responsibility to do something about the situation. During the last quarter century, the Committee has had jurisdiction over much of the nation's federally-funded, civilian scientific and technological development, and this remains our responsibility. Thus, this Committee must occupy a central role in the national examination of the United

States as a technological innovator, a manufacturer, and a trader in high and low technology products.

However, our Technology Policy Study must look also to broader issues and factors such as availability of capital, technical education, government regulation, and innovation, which must come together in order to advance technology in a sustained and consistent manner.

The Committee on Science, Space, and Technology considers the undertaking of a Technology Policy Study to be a major priority in carrying out its jurisdictional responsibility to the Congress and to the nation. We trust that our effort will be able to provide not only a unique perspective but also an agenda of recommendations for national action.

2. THE CHALLENGE WE FACE

The significance of technology as one of the pillars in the American economic system is well-recognized. The country owes much of its high standard of living to its technological pre-eminence. However, a number of indicators suggest that the U.S. may be living off past technological successes and investments. U.S. industry is now facing, for the first time in many years, technologically equal, and well-organized foreign competition backed by concentrated fiscal resources, comprehensive industrial policies, and protected home markets.

The setbacks suffered by the U.S. as a competitive nation cannot solely be blamed on macro-economic factors, an over-valued dollar, high wages, or unfair trade practices by its trading partners. Foreign competitors, in many cases, have managed their technology for the long term, have paid more attention to quality, and have been better able to grasp and adapt to opportunities in a technologically competitive world. They have paid attention to modern manufacturing techniques and processes and have designed and produced higher quality products. Many of those products have been better suited to the international market and even to the U.S. market.

This situation raises new questions about the need for a well-defined, intelligently constructed, long-term, consensus-based technology policy; a policy which is consistent, with American political philosophy and democratic ideals. The Technology Policy Study by the House Committee on Science, Space, and Technology should examine the relevant factors and develop agreement on the roles that the Federal Government and the private sector can and must play in reaching viable solutions. The Study should establish what policies must be pursued by our government to ensure that the right environment for scientific research, technological development, marketplace success, and sustained growth is created and maintained.

By undertaking this Study, the Committee on Science, Space, and Technology, and its Technology Policy Task Force will take the lead in examining the long-term problems and structural change that may be needed, and will attempt to establish a framework for legislative initiatives in the coming years. At the same time, when carrying out the Study it is important to keep in mind that the na-

tion's continued ability to compete industrially is both a basic responsibility and a right of the private sector.

The concept of a federal role in the direct support of scientific advancement for the nation emerged at the end of World War II, particularly through the rationale outlined in Vannevar Bush's *Science, The Endless Frontier*. This support has grown over the ensuing four decades. Today, it is acknowledged and accepted that the Federal Government has responsibility to provide significant support for the nation's scientific research.

The proper role for the Federal Government in the process of fostering technology development is less well understood, defined, or accepted. Yet it is technology, in one form or another, rather than science, that most clearly affects the lives of the nation's citizens. It is by the creation and diverse utilization of technology that, historically, we have measured the progress of civilization. It is primarily through the development and diffusion of technology that the flow of modern business and commerce takes place.

America does not have a formal and articulated policy for stimulating and guiding technology development. We do have numerous laws as well as many ingrained patterns and practices that govern the way that we envision, develop, and utilize technology. These guidelines and influences, viewed collectively, form an "ad hoc" national policy for technology. Given the questions about the performance of the United States as a competitor in the domestic and international marketplace, it seems timely to examine this "ad hoc" policy for its strengths and weaknesses; it seems necessary to ask whether a formal, articulated policy is needed to help us better compete in the changing and complex world economy, and it seems critical to identify the real problems and propose practical solutions. A visionary Congress should initiate dynamic public policy to insure the development and maintenance of national strategies for maximum utilization of our nation's knowledge and expertise in science and technology.

3. HISTORICAL PERSPECTIVES

Abraham Lincoln said "If we could first determine where we are and whither we are tending, we could more readily agree on what course to take and how to get there." Our first task will be to establish and understand our present condition. We shall then analyze current trends. We will take a cautious view about the uncertain terrain of prognosis, recognizing that we will miss the mark often, but also recognizing that thoughtless venturing into an uncharted future is folly.

In this study we shall establish an historical perspective on the relationship between the advance of technology and the factors by which we measure progress, such as standard of living and rate of productivity growth. This will provide a better appreciation for the role that technology has played in the development of our civilization over time, and for the ways man has benefited from technology. We will undertake a review of the institutions which have traditionally played an important role in the development of technology in the U.S. in order to assess the extent to which this role has changed in recent times.

At the same time it must be borne in mind that exhaustive historical studies on these issues abound. While a degree of redundancy may serve a worthwhile purpose, it would be unproductive to be merely repetitive. Thus, at the outset we shall commission a bibliographic study of the literature relating to technology in the historical context.

Then, in our Study, we shall try to come to grips with such historical enigmas as: (1) the relationship and interdependence between science and technology, (2) the degree to which our previous industrial successes are the result of our decentralized free-market system, vis-a-vis the blessed accident of resources and geography, (3) the unanticipated results of technology on the functioning of society, (4) the unintended results on technology that occur from a given Congressional action because of the complex influence structure, and (5) the degree to which history can provide guideposts for a society which changes and in which change itself is accelerating.

4. A FEDERAL TECHNOLOGY POLICY OVERVIEW

In considering the prospect of defining a clearly articulated national policy for technology, we must ask: What should be the objectives of such a proposed policy?

First, the policy would foster an environment that nurtures private sector technology development and commercialization. It would provide direct public support for improving the technology base for the various vital public goods that permit the society to function as a whole; such as defense, transportation, education, and waste disposal. The policy would also provide guidelines for determining what, if any, federal support should be provided for industries deemed strategic to the nation's manufacturing base.

The second provision is one of negation. The Federal Government would refrain from pre-empting industrial planning. We believe that our decentralized decision-making process is inherently superior in terms of maximizing incentives for both innovation and flexibility.

Third, it would ensure the effective use of government laboratories and agencies in achieving strength in the longer range technological areas not yet ready to be addressed adequately by the private sector.

All recommendations for change that might come from this study or the welter of other studies should be evaluated in terms of these three fundamental axioms.

5. SCOPE OF THE STUDY

The study of American technology policy will focus on those factors that are crucial for achieving the national goal of economic strength through industrial and technological leadership. It will examine the role of the Federal Government in the advancement of technology, exploring those factors which directly and indirectly affect everything from original innovation to the achievement of commercialization. The organizing question is: What public policies enhance the creation and exploitation of front-rank technology and what policies inhibit them? Fundamental factors of direct influence that will be addressed include such things as research and develop-

ment, the climate for innovation, technology transfer, patents, and education in science and technology.

Indirect but significant impacts on the creation, diffusion, and utilization of technology come from trade and foreign policies, the federal budget deficit, antitrust policy, and tax policy. These factors will be examined as part of the Study for the purpose of determining how they assist or hinder the innovation process, and the transfer and utilization of technology for a competitive nation.

The Study will be carried out in two parallel channels. One thrust will try to analyze what the world of tomorrow will be like, and it will study the processes that the U.S. should follow in preparing for that long-range challenge.

The second thrust will be much more pragmatic and immediate. It will consist of a sequence of case-studies in which we look at the technologies of several American industries, some of which are traditional and basic, some of which are newly burgeoning. We shall trace the pathways these industries followed in arriving at their present state and we shall make suggestions for Congressional action if the Task Force finds that action is indicated.

6. STUDY OBJECTIVE AND OUTLINE OF PRIMARY STUDY TASKS

The objective of the Technology Policy Study is to identify basic problems and make recommendations on policy for technology that represent a cohesive and consistent national approach in support of technology development and utilization for the nation. The study will include the investigation, collection of data, synthesis, and development of findings related to:

A. The responsibility of the Federal Government for technology support and development.

B. The influence that Federal Government budget mechanisms and procedures have on our nation's long-term ability to develop and apply technology

C. The need for increased cooperation among the various levels of government (federal, state, local), the private sector, and our educational institutions to foster the utilization of science and engineering data for technology development.

D. The preservation of key technologies, industries, and skills that are required for the constant evolution and growth of society.

E. The necessity to improve the competence and skills of our human resources by better education and training, especially through increased emphasis on science, engineering, and related technical disciplines.

F. The impact of government policies and regulations on the ability of the private sector to develop and utilize technology for the efficient production of goods and services.

G. The need for developing new mechanisms to aid in the transfer of technologies and expertise from the federal sector to the private sector in order to take full advantage of the large federal investment in science and technology.

H. The influence of the private sector's business strategies on the way that business responds to technological advancement.

I. The ways in which state and local governments contribute to or inhibit technological innovation and development.

J. The implications of foreign involvement in U.S. research and development.

7. ISSUES FOR CONSIDERATION

A. THE FEDERAL GOVERNMENT

The boundary between the government and private sector responsibilities in technology development is dynamic, and often changes to respond to needs and emergency situations both domestic and international. However, when the Federal Government shifts its emphasis primarily to basic research, and concomitantly industry reduces its efforts to only product improvement, the gap between government effort and private sector initiative widens to a breadth where the result of each sector's work remains autonomous instead of being complementary or forming a continuum from laboratory to marketplace. In this scenario, it is possible to produce eminent science and yet fail in market competition. Thus, it is important that the government help in promoting the link between the conduct of basic research and commercial development of technology.

The oscillation of federal support for science and technology from funding only basic research to the funding of the development and demonstration of technologies, has been based sometimes on the perception of crisis situations, frequently on the philosophies of different administrations, and occasionally on the composition of Congress. Without consensus on guidelines and a view of the long-term consequences, we will continue to see these wide arcs in the pendulum's swing. These fluctuations undermine our national capability through the loss of vital technologies, the dissolution of experienced development teams, the stagnation of promising projects, and the abandonment of costly and first-rate facilities.

Despite the continuing debate about the extent of the government's role in the development of technology, it is undisputed that government actions, rules, regulations, and spending levels impact the private sector's decisions in the marketplace.

Given these understandings, there are questions to be posed regarding the nation's "ad hoc" arrangement of dealing with technology issues.

How does the present ad hoc policy work? How is it consistent or inconsistent in its various parts? How effective is it? How can it be improved?

What are the advantages and disadvantages of America's approach in its attempt to compete with other industrial nations that exercise more central control and planning, and provide more direct funding of industrial technology development?

How can we work within our decentralized decision-making process to maximize the development and transfer of technology?

In examining policy for technology, we will seek an incisive approach that will deal with the specificities of how and where technology is generated, promoted, and marketed, and how the government can be effective in participating in these activities. We will investigate the impact of Federal Government policies, legislation and regulations on technology development in the private sector.

Because industry must bear the major role in the development of products and services, it is important that all aspects of government policy be examined for their influence on the willingness and the ability of the private sector to invest in the needed technology base.

There are a number of factors extraneous to technology, *per se*, that nevertheless have significant influence on the way technology is developed and used in our society. Such factors include tax policies, antitrust policies, environmental regulations, security considerations, and investment decisions. All of these factors are part of the national "overhead" on our products and services.

(1) TAX POLICY

The new federal tax policy, as well as local and state tax policies, should be examined for their impact on technology development and commercialization in the private sector. All the ramifications of the new tax structure will not be clear for years to come, but it is advisable to monitor the situation carefully on a continuing basis.

Additionally, the Economic Recovery Tax Act of 1981 contained an incentive for investors to improve corporate risk-taking by providing for a 25% tax credit on increases in R&D expenditures.

In order not to revisit an issue thoroughly addressed by the previous "Science Policy Study", the Technology Policy Study should incorporate the information from the SPS on the R&D tax credit and its effectiveness in promoting private sector R&D.

Issues

a. Although the current tax policy is too new for profound interpretation, what kind of business activity and commercial development does it appear to encourage?

b. Where does it seem to create greater impact or disincentive than previously existed?

c. Does current tax policy provide any incentive for industrial investment in new manufacturing or process innovation technology? If not, are tax policies a reasonable vehicle to encourage industry in these investments?

d. Were state tax policies a factor of encouragement for the location and development of Silicon Valley, Route 128, and Research Triangle Park?

e. Have other states with innovative economic development programs remodeled their state tax policies to enhance the development efforts? If so, what can we learn from the examples?

(2) COST OF CAPITAL

A problem facing many weak sectors of U.S. industry is how to undertake the considerable capital investment necessary to make

technological and other changes essential to meet import challenges and global opportunities. The cost of capital in the U.S. compared to Japan, for example, is an often-raised issue. In Japan the cost of capital is one-half to one-fourth of that in the U.S. A decision to move ahead with an R&D project or a new manufacturing plant in the U.S. would require a return on investment which is higher or is recovered over a shorter period than in Japan.

In large part the emphasis on producing immediate financial results that show in the quarterly returns for an R&D investment is not only due to American impatience, it is a recognition of the high cost of our capital.

Issue

a. What mechanisms can be initiated that will meet the long-term, low-cost capital needs of industry and that will also preserve the institutional autonomy of our financial organizations?

(3) ANTITRUST REGULATIONS

The nation's antitrust laws were established to safeguard open competition among businesses within an industry. Today, however, the increasing competition facing U.S. industries from abroad has resulted in pressure for changes in U.S. antitrust policy beyond the joint venture R&D modification of recent years. It is proposed that when considering whether specific merger proposals would be actionable, judgement should be determined by measuring world market shares rather than only domestic market shares.

Issues

a. How can the Federal Government help promote the successful interaction of corporations and small businesses so that they can operate from a complementary and synergistic posture in our economic structure?

b. Although domestic competition within an industry serves to strengthen and diversify the individual corporations of that industry, does this domestic intra-industry competition work to the disadvantage of the industry as a whole in its ability to compete internationally?

(4) TECHNOLOGY TRANSFER AND EXPORT CONTROL

In the early days of the industrialization of America, United States' businesses had no hesitancy about borrowing from more technically sophisticated nations. With our surge to world leadership after World War II, we became the nation that was copied most and even pillaged. In very recent years it has become evident that we are again in a position where it is dangerous not to know of the advances and breakthroughs that are occurring abroad. Independent R&D is increasing in all major countries. But our insularity and our sense of the superiority of our system is preventing many in both government and industry from dealing with our international competition in a realistic fashion.

At the governmental level, the U.S. Foreign Service officers who staff American embassies throughout the world are our nations' official personnel network around the globe. Both our science at-

taches and our commercial attaches abroad represent an important resource for gathering useful technological and commercial information. We will examine whether they should be better qualified for their task and whether they should be utilized more assiduously.

As alluded to earlier, the use of export controls by the U.S. to prevent transfer of technologies of national security importance to the East Bloc countries is estimated by the National Academy of Sciences to cost U.S. export businesses \$9 billion in lost overseas sales annually. The U.S. frequently has been considered an unreliable supplier because we require export licenses for forty percent of all manufactured goods sold overseas. This has driven some customers to shift to foreign sources for the same goods. There is a need for Congress to establish responsible rules to mitigate this situation.

Issues

a. What is the status of efforts to enhance access by U.S. industry to foreign sources of industrially-relevant, research and technology? How can these efforts be improved?

b. What are the implications for U.S. technological competitiveness of the quite open access we provide for foreign nationals to American universities and U.S. government laboratories? What are the unresolved issues involving the access of foreign nationals to our federal laboratories and universities?

c. The goal of the Japanese Technical Literature Act is to increase access to Japanese scientific and technical information by expanding federal efforts to monitor Japanese technical activities and disseminate the information. Is the process working? Are there other ways to accomplish the goals of this Act? Should this effort be extended to include other countries?

d. Should and can U.S. technological knowledge be protected from foreign competition? What are the implications of foreign companies supporting research in American universities? What level of U.S. technical information should be contained within our national boundaries through export control and what is the level where this control becomes counterproductive for the economic vigor of the nation? How should we deal with multi-national corporations?

Federal Institutions

(1) THE NATIONAL LABORATORIES AND CIVILIAN AGENCIES

The non-defense R&D spending by the Federal Government is heavily weighted toward basic and applied research. Most of the federal support for technology resides in the mission agencies such as the National Aeronautics and Space Administration, the Department of Energy, the Department of Agriculture, and the Department of Defense.

The bulk of the non-targeted, federally supported science research and education is centralized in the National Science Foundation. Within the Federal Government there is no equivalent structure for the focus and support of technology and applied engineering research and education. Several bills have been introduced

in Congress, such as the National Technology Foundation bill, the Advanced Technology Foundation bill, and the National Professions and Technology Foundation bill, which propose a more focused approach by the Federal Government for technology support. The President's Commission on Industrial Competitiveness has proposed setting up a single agency, the Department of Science and Technology, with responsibility over technology development as an alternative to the pluralistic approach presently used through mission agencies. The Study will examine the advantages and disadvantages of both the present pluralistic approach and the proposed more centralized alternatives.

The national laboratories represent a major federal investment and constitute an important national resource. There are more than 700 research facilities currently operated or paid for by the Federal Government. The budget for research and development in the federal laboratory system was approximately \$15 billion in 1986. These facilities have extensive science and technology resources devoted to carrying out mission responsibilities. However, none of these laboratories has the prime responsibility of developing commercial technology or acting as a well-spring for the nation's industrial base. Nevertheless, a number of legislative attempts have been made to increase the availability of information generated at our national laboratories to private sector industries and businesses. Despite these attempts, the rate of commercialization of federally owned patents, has remained low.

An emphasis on technology transfer from national laboratories to help U.S. industry implies two things: first, that the laboratories have something to transfer that industry can use or need; and second, that the private sector has the motivation, the internal mechanism, and the available capital to take advantage of the R&D results from the laboratories. Even under the optimum conditions in diversified corporate research centers, with well-established communication channels and diverse corporate needs for improvement, the transfer of R&D results within the company does not occur as a simple, natural process. In institutions primarily set up for a specific mission, such as the national laboratories, technology transfer is even more difficult.

The R&D pursued by the federal laboratories is organized to meet certain definite purposes or missions determined by the government's needs. There is no commercial use in mind and there is no common investment at risk. Thus, technology transfer necessarily has been secondary to the intended mission.

Issues

a. What would be the most effective institutional framework for the Federal Government to buttress technology and provide assistance to commercial engineering practice?

b. What are the advantages and disadvantages of the various approaches to setting up a technology counterpart of the National Science Foundation?

c. How effective has the Stevenson-Wydler Act been in promoting technology transfer from the federal laboratories to American industry? Should the laboratories be restructured to serve, in part, as technology centers for both key mature and emerging technologies?

d. What is being done presently to transfer and disseminate the results of government R&D investments to the private sector?

e. How can the federal laboratory system be used better to link the academic and private sector endeavors in a way that truly optimizes the work of all three sectors?

f. How do the differing organizations and operating mechanisms of each of the mission agencies affect the way each develops and promotes technology?

(2) THE DEPARTMENT OF DEFENSE AND MILITARY LABORATORIES

Military needs have dominated the federal R&D expenditures in the 1980's. In 1987 about 70% of the federal R&D budget is devoted to defense research and development; about 87% of federal R&D obligations to industrial performers are from the Defense Department. In terms of the percentage of GNP devoted to civilian R&D, the United States spends far less as a percentage of its GNP on civilian science and technology activities than do its major economic competitors. In part, this is because U.S. spending patterns are necessitated by U.S. obligations to maintain Western defenses. Yet, as we have indicated, these patterns have implications for the utilization of both scientific and technical personnel and national resources that might otherwise go to civilian technological development activities. Spin-offs from the military and space-oriented technologies tend to have long-time horizons and be indirect. Those technological benefits that are derived from defense-related technologies cannot be planned nor guaranteed.

Issues

a. What are the effects of defense spending on the climate for innovation and growth in U.S. high technology industries?

b. If military research funding escalates substantially over the years, what are the likely consequences of employing so many U.S. scientists and engineers in this endeavor?

c. The arguments in favor of "spin-offs" from military research can be placed in context by assessing the history of the same argument for nuclear power development and aerospace development. In this regard, what have we learned from the technology transfer programs of the AEC and NASA?

d. It has been alleged that many U.S. systems are now dependent in critical ways on components and systems from other countries, i.e. electronic chips. This is in addition to the traditional concern for dependence on foreign sources of raw materials. What are the "real" rather than the rhetorical proportions of this problem? What would be the impact for U.S. security if the United States were not self-sufficient in the production of defense technologies?

e. How can defense R&D programs be directed toward producing dual-use technologies that will serve both defense needs and have commercial adaptability? Should more of the basic defense-sponsored research be funded through agencies other than DOD, so that technologies may be transferred to DOD rather than the other way?

f. Can a strong and progressive defense industry be maintained without an equally strong, innovative, and competitive civilian industrial sector?

B. PRIVATE INDUSTRY

The free enterprise system, with its basic tenet of open competition between individual businesses within a given industry, is a firmly established American tradition. Over the years it has yielded this nation a rich harvest of goods and services. Most of our new products and new inventions have come from private industry and it has been the source of gainful employment for much of our citizenry.

The private sector supports over half of the nation's total R&D funding. It employs the majority of U.S. scientific, technical, and engineering personnel. U.S. companies often start in front of the competition and stay ahead in areas where the technology is changing rapidly. As the technology matures and as the pace of radical change slows, other countries close in quickly and often overtake the American commercial effort. This seems to be, for nations such as Japan, the result of emphasis and sensitivity to product quality, reliability, appeal, and marketing. Put another way, U.S. industry often develops and markets new products, only to have foreign competition command market-share soon thereafter.

The U.S. private sector is composed of a unique amalgam of small businesses and large multi-purpose corporations. It must be borne in mind that small businesses and large corporations are vastly different commercial entities, differing in more than just magnitude. Each type of enterprise plays a unique role in our economic structure. Small technology-based businesses can be a particularly rich source of creativity and innovation in defining new market niches, while large corporations bear the burden of high-priced process and product development/innovation.

Our deep concern for the state of innovation and technological competitiveness has resulted in more attention being given to U.S. small businesses. Small firms, particularly in the high-tech sector, have often grown out of a single bright idea which develops into a product or service. However, over the long haul, these firms may be outperformed as the result of their inability to sustain a research and development program or to acquire the necessary capital to perform product improvement, marketing, and manufacturing capability.

The business of large corporations primarily involves the sales of product and process in major orders of magnitude. The U.S. military establishment and our space agency have been significant customers for many large corporations and our nation is the acknowledged world leader in the area of military and aerospace technology. This is probably due to the fact that these are areas which have received generous government funding and attention. The Study will describe how the R&D investment by both industry and government breaks down by sector. We will determine what influence the emphasis by government on specialized sectors of the economy has on private capital investment and technology development.

Issues

a. What new methods and mechanisms can be used by the Federal Government to support technology and product development in the private sector?

b. Is the Small Business Innovation Research program effective in giving small business staying power and follow-up capability after initial investment?

c. Has the small business emphasis worked to the detriment of large corporations and competitiveness?

d. Does the Federal Government's emphasis on defense procurement and defense R&D result in producing a weak competitive position by the private sector in other areas of commerce?

Another area of concern is the number of mergers and takeover bids that have occurred in the U.S. industrial sector over the last few years and the resulting restructuring of the industry. This may have affected U.S. industry's ability to perform long-term, competitive R&D. Eventually, there are debilitating consequences for industry when long-term investment in research and development is sacrificed for near-term profits.

Product liability, particularly when new and unproven technologies are involved, is becoming an increasingly inhibiting factor. The high cost of liability insurance in the U.S. is threatening many small businesses and curtailing the development and availability of both consumer goods and services.

In addition to the foregoing specific concerns, there is a need to examine industry from a broad perspective. It is normally assumed by American economists that the market should determine what industries we will have. However, from a national security point of view, some industries may be more important than others. These would include sectors which supply the basic needs to maintain an industrial base, such as energy and raw materials, machine tools, and electronic chip manufacturing. It appears that many of our industries that are of national importance are in danger of being lost as the result of foreign competition and soft market conditions. It is time to determine what policies and actions are required to ensure that the U.S. brings with it the necessary mix in the "technology luggage" for our travel to the future.

In some cases, although the loss of a complete industry is not involved, we are seeing much the same effect from the trend toward "outsourcing" of component manufacturing by U.S. firms. This is particularly true in the high technology industries such as consumer and defense electronics. This practice has allowed the U.S. firms to remain competitive at least in the U.S. market against imports from other nations. However, the resulting jobs-export and off-shore production by U.S. corporations can have widespread ripple effects through other parts of the U.S. economy.

Aside from the question of whether certain industries are indispensable, there is an existing, albeit not prevailing, question of whether manufacturing industry, *per se*, is indispensable. This query is based on the view that a natural transition from a manufacturing and technology-based economy to a service-based economy takes place in an advanced industrial country. The underlying premise is that mature and labor-intensive industries will be more

economical in countries that have low labor costs and that are closer to raw material sources. We do note that the U.S. trade deficit in manufacturing goods has been in part offset by a trade surplus in services.

Today there is a growing awareness of the increase in the number of service industries as a component of our economy. However, there is only limited data and understanding on the composition of this diverse and complex sector. It is important to increase our ability to assess the possible implications of the service industry growth on our overall economic balance and autonomy.

The Technology Policy Study will seek to determine to what extent the U.S. can sustain a service-based economy without a competitive manufacturing and technological base. We must ask whether we can continue to expect a high standard of living in a service-based economy. The Study should examine whether the U.S. can continue to prosper while being a service supplier to the manufacturing base of other nations.

Issues

a. Is it critical for the long-term health of the U.S. economy and our military security to sustain certain basic and key technologies or industrial sectors whether or not they are competitive? If so, what are they and how should they be sustained? Conversely, where can we safely depend on foreign sources?

b. If R&D, engineering, and product-development are separated from manufacturing through off-shore production, can technological leadership be maintained?

c. Which emerging patterns related to service-industry growth are indications of necessary and natural transitions, and which are indicative of pervasive weaknesses?

d. What is the impact of high technology on the service sector?

C. EDUCATION AND HUMAN RESOURCES

Probably the institution of which this nation can be most proud, short of the Republic itself, is its system of education, both private and public. No other nation of any significance can boast of a better overall system for offering unlimited opportunity to all of its citizens. Nevertheless, in a system as diversified and independently organized as ours, there must be constant vigilance as to quality and relevance.

At present, there is a special concern throughout the nation about education in mathematics and the sciences as well as the training of highly skilled artisans and technicians that support technology development and application. It is generally accepted that the future of the nation's international competitive posture is dependent on a cadre of highly educated and trained people across a broad range of disciplines. Such education should range from producing front-rank scientists, engineers, technicians, and mechanics to creating an informed citizenry that is knowledgeable about technological issues.

Anyone familiar with the American education system recognizes quickly that our problems are most acute at the primary and secondary school levels. It is at these levels that we are falling behind

our more motivated foreign peers. It is here that science and math education must prepare students for life in a high technology world. Vocational training for gainful employment in our increasingly sophisticated technological society must be provided at secondary school levels for the many students who choose to terminate their formal education with high school. A technologically literate workforce is mandatory in order to compete in the global marketplace.

Our problems in K-12 science and math education must also be addressed now to insure that there will be future generations of scientists and engineers to carry on America's tradition of scientific and technological excellence. We will need eminently qualified people to do research at our national laboratories. We will need the best trained and experienced people to teach the science and engineering disciplines at our universities and to conduct research there. But to accomplish this, we will need first to increase dramatically the number of highly qualified science and math teachers throughout our K-12 school systems. We do not need further study or analysis of the primary/secondary situation. There should be direct and immediate action.

On the other hand, university and community college education present quite another scenario. One can always look for improvement in any situation, but improving education at the college level does not fall into the crisis category.

Unlike most foreign countries, and particularly unlike our more serious foreign industrial competitors, in America the bulk of first-rank science is performed in universities. In most foreign nations scientists are based in institutes, academies, and government laboratories. The net result is that foreign scientists do work that is much more reflective of the pressures and priorities of the central government.

The American system has produced scholarly pre-eminence as is attested to by our Nobel Prizes and other symbols of scientific excellence. But the tradition of free scholarship that leads to scientific breakthroughs does not lead to a direct concern for the technological problems of industry.

Pre-eminence in science alone does not lead to technological leadership. Investment in basic science is translated into social benefits only through the complex process of engineering research and application. As Dr. Lewis Branscome, the former Chief Scientist at IBM, has said, "Translation of knowledge into the marketplace is a difficult art."

Over the years science and technology have continually advanced and enhanced each other. Technology has consistently facilitated the ways that scientists have been able to search and probe the unknown. The knowledge and discoveries uncovered by science frequently form the basis for developing new technologies and techniques. There are also new and important technologies that are based on more or less direct applications of new scientific breakthroughs. The recently established engineering research centers at our universities were specifically designed to deal with the pragmatic problems of developing new technology.

The relationship between post-secondary education and the development of technology for the nation can best be addressed by considering the following.

Issues

a. An educated public is the greatest resource of any nation. In today's world it is particularly important that our citizenry be "technologically literate". Beyond improving primary and secondary school instruction and learning, what steps would be most effective in providing Americans with an appreciation of science, mathematics, and technology?

b. For high school graduates who do not have the inclination, motivation, or ability to attend college, how can the Federal Government help community colleges and vocational schools play a larger role in providing these students with the opportunity to gain skills that will better prepare them for jobs with firms and industries in technology areas? What are the results of previous vocational education and basic skills programs sponsored by government and industry? How are technological advances and innovative production systems expected to change skill requirements?

c. Given that many of the nation's finest scientific and technical minds are concentrated in our universities and that the incentive system in universities does not reward product development, how can we best influence this talent pool to concern itself with the technological problems of industry?

d. Should science and engineering programs have a strong humanities and social science content, and the liberal arts programs have a strong technical content?

e. Should manufacturing technology and the management of technological change become a large part of the business school curriculum?

f. Should the universities and colleges be more concerned with providing engineering students broad-based training in science and mathematics, with speciality training left to private industry?

g. How can we ensure that sufficient numbers of engineers and scientists in the various disciplines are available to the job market when needed? Can dependence on pure market demand be accepted when it takes at least four years or more in the educational system for achieving minimum engineering competency? Should the universities and the federal R&D system (e.g., national labs) be used as a repository for scientists and engineers, or should industry be encouraged to provide for a larger portion than they need?

h. Without retraining, engineers become outmoded within 5-7 years. Out of concern for the individuals and concern about industry's need for competent engineers, programs of continuing education are required. How well is industry, particularly small business, coping with this problem? Are community colleges playing as significant a role in addressing this problem as their proponents claim? Does the Federal Government have a role to play in the retraining?

i. Both government and industry have played a role in retraining workers from declining industries. Under what conditions have these programs been effective in helping workers find alternative employment?

j. How can federal policies for the support of engineering research and education supplement the private sector by providing a stronger and more stable framework for confronting a technologically-dependent future? Should such university support be concentrated in a single agency, such as NSF, in a new agency without NSF's basic research mission, or is the existing plural mission agency approach better?

D. STATE AND REGIONAL ECONOMIC DEVELOPMENT EFFORTS

One of the heartening developments on the American technological scene is the spontaneous generation of the high-tech industrial activity in local areas such as Route 128 near Boston and in Silicon Valley in California. A more planned and programmed effort in the Research Triangle Park area of North Carolina has also been successful.

Stimulated by these examples and recognizing the need to foster new technologies in their areas, many states and localities are investing their own resources to attract and generate new industries.

Issues

a. What is the history of local and state efforts to foster technological innovation and regional economic development? What should the federal role be in fostering such developments? What can state and local government do that the Federal Government cannot?

b. In what ways have state and local governments discouraged technological progress?

E. FOREIGN ENTITIES

The Study will survey and analyze the institutional and operating mechanisms of the highly successful foreign industrial nations. Our intent will not be to advocate adoption of their methods. Rather it will be to learn through a better understanding of their methodology and approach how to provide America optimum advantage in its competitive commercial dealings with these nations.

It should be noted also that there is no inherent prejudice against changing our ways to foster improvements, but that intent should be served in ways that retain our own unique identity and institutions, not through mimicry.

8. CASE STUDIES

As indicated earlier in the Agenda, part of the Technology Policy Study will be conducted through a series of case studies. These case studies will be used as mechanisms for examining industrial sectors, both new and traditional, and the evolution of their emergence to their present posture.